Maritime Domain Awareness Technology

There is no silver bullet, not now, not in the foreseeable future.

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Collection

Since September 11, 2001, several Maritime Domain Awareness (MDA) Concepts of Operations (ConOps) have been written by a variety of organizations. Each of these MDA ConOps assumes some form of layered zones of surveillance and defense, from well offshore, to point defense of high-value targets within our ports and adjacent waterways. Those high-value targets include not just significant ships, but also port infrastructure or other targets of high economic, political, or military value. These include power plants, sewage treatment facilities, chemical plants, critical bridges, historic monuments, and the like.

In the past two years at least four different groups have studied what collection systems (platforms and sensors) are needed to support the core MDA ConOps and what technology is available or will be in the near future. Thus, whatever specific MDA ConOps plan is finally agreed to by all concerned, the basic technology to carry it out is reasonably well understood. Possibly the numbers of one collection system or another, and the "where" and "how" of data fusion and analysis, or exactly what the decision-making sequence will be, may change slightly, but the basic technology will remain pretty much the same.

Each of the studies referenced above have basically concluded that no one system can do it all, even in a single zone, much less across all zones of defense. Maritime Domain Awareness requirements span areas from coastal and harbor defense surveillance and warning to persistent and pervasive surveillance of the broad ocean area. The bottom line is that we will need "systems of systems" in each zone. Much can be gained by netting what we now have to build a collaborative information environment, with a user-definable interface, to arrive at a robust user-defined operational picture. But if we are to provide persistent and pervasive surveillance of all the areas needed to establish Maritime Domain Awareness, we will need both more and better surveillance systems.

We also need the means to process, fuse, and analyze all available data; make accurate decisions; and interdict any suspicious vessel before it enters any of our ports or approaches anything of value to us or to our allies and partners. Indeed, to build a warning system without a commensurate total system through to a robust interdiction capability just means that someday, somewhere, someone is going to die "all tensed up, rather than just surprised" to quote RADM Chuck McGrail, an old U.S. Navy fighter pilot friend of mine.

Data-Collection Systems
The types of sensors currently within ports and in coastal areas are well known, such as radars, various types of cameras, and potential self-reporting systems such as the automatic identification system (AIS), and other transponder-based systems. Nontraditional sensors include various types of "measurement and signatures intelligence" sensors, the most well known of which is as the passive coherent location sensor (PCL), which exploits the reflections of the emissions of nonradar transmitters, such as TV and radio, to determine an object's location. However, this paper will primarily focus on just the technology needed to detect vessels well offshore.

Let's look at what collection systems (platforms and sensors) technology have come to the attention of the MDA Program Integration Office since it stood up nearly three years ago.

Far-Reaching Technology

There is a documented need for a range of sensors and platforms. In the broad ocean area there is a need for surveillance of non-cooperative vessels that are not emitting and/or are not complying with reporting requirements. This requirement is generally acknowledged and a number of changes to methods of operation and technologies have been proposed to accomplish it. These changes are nearly all upgrades to existing systems and methods. There is one technical exception, a special type of PCL, but we will get to that.

It is generally agreed in the technical community that the successful implementation of any MDA ConOps also requires at least significantly upgraded sensors, if not totally new ones. Furthermore, we need to change the mode of operation from being reactive to being proactive. This means that a sensor must always have ready access to an area of interest (AOI) regardless if there are targets or not. Developing baseline time histories of images in AOIs is critical to understanding what is normal and what should be considered an anomaly and perhaps a suspect.

Currently the United States owns three active relocatable over-the-horizon radars (ROTHR), being used primarily to provide air surveillance of the southern approaches to the United States. Using sky wave bounce techniques, ROTHR has a range of some 2,100 miles. ROTHR has also demonstrated a capability to detect surface craft but has a negligible R&D budget to further develop this much-needed capability. The Australians have a similar system, looking north, and they have an extensive R&D effort underway to make this system capable of surface surveillance. There is an ongoing joint U.S.-Australian project arrangement studying how a better over-the-horizon radar system could be developed. Currently there is a proposal to conduct an advanced capabilities technology demonstration on the ROTHR to examine and validate new technologies for emerging threats. These efforts show substantial promise.
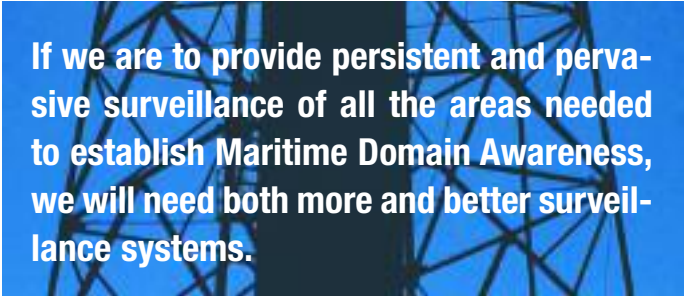
Long-range sonar detection of surface traffic has long been understood, but our current system, the Integrated Underwater Surveillance System, is oriented in such a way that it will not provide complete optimal coverage of the areas of interest and the cost to modify/update/reorient it to provide such coverage is a budget-buster. Advanced sonar systems deployed as trip-wires in certain high-interest areas such as in the Florida Strait; in the Mona Passage between the Dominican Republic and Puerto Rico; and off Brownsville, Texas and San Diego, Calif. may have high utility as part of a system of systems, but solving the radar surveillance problem must have first priority.

Foreign government and private space systems may well have a role here. The Canadian government currently operates a radar satellite and it has been sufficiently successful that a launch of a much more capable system, RADARSAT 2, is planned. Canada is expected to launch an additional three to six radar-equipped satellites within the next decade, most, if not all, with AIS receivers. Canada has also developed its own ship-detection software called "OceanSuite" and the various satellite processors have been designed to complement each other to optimize ship-detection performance.

Another large player in the area of civilian space for Maritime Domain Awareness is the Center for Southeastern Tropical Advanced Remote Sensing (CSTARS), at the University of Miami. It, in cooperation with Vexcel Corp. of Boulder, Colo., has developed "OceanView™," a software program that allows for the rapid analysis of any commercial imaging system to determine if there were vessels imaged. It can generally tell the size, type, course, and speed of the vessel imaged from civilian spaceborne radar and electro-optical mono, multi, and hyper-spectral systems.

Of course, there are only about eight current civilian space-imaging systems in orbit today, but several
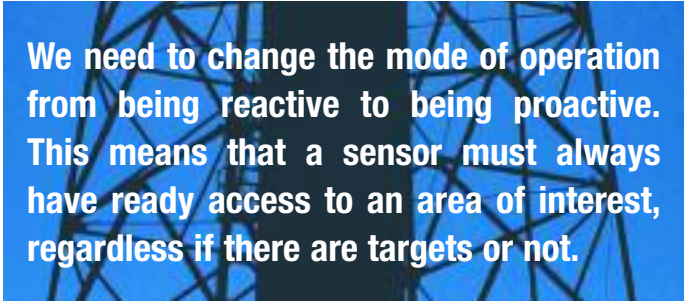
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companies/countries have plans to add more. CSTARS is taking steps to improve processing of the images. It also hopes to gain additional access points by establishing mobile downlink sites in such places as the Azores and/or other locations in the western U.S. to allow for wider collection opportunities.

U.S. Customs and Border Protection (CBP) operates a fleet of highly modified P-3 fixed-wing aircraft with superb ocean surveillance capabilities and has recently begun installing AIS collection capability into these aircraft. Likewise, the Coast Guard is installing AIS in its aircraft. The tactics, techniques, and procedures to make the most of this new capability are only just now being investigated. This could well provide a paradigm shift in the way other U.S. aircraft are outfitted for maritime surveillance.

The above systems are the primary offshore collection systems in use today. None are optimized for the Maritime Domain Awareness mission, but work is underway to understand how best to do just that, to optimize them to provide much more robust ocean surveillance. One effort that appears to have great promise is the near-real-time integration of the ROTHR with the output from CSTARS, and auto-

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matic identification system data collected by the Coast Guard, U.S. Navy, and CBP aircraft and vessels.

Co-incident collection of AIS data would allow for both CSTARS and the ROTHR to calibrate their sensors by providing ground truth on the position, size, course, and speed of the images they are currently collecting. Having a sufficient amount of this type of data would allow engineers to develop algorithms to extrapolate the findings to other cases. A joint offshore test concept development meeting was held at CSTARS in July 2006 to examine how to implement this concept.

The Future
The next system under discussion is a bit further away from fruition, if it ever gets there at all. Several years ago, NASA engineers placed a passive coherent location receiver/processor system in a business jet to see if they could use the energy transmitted down from several classes of spacecraft, including the transmissions of the global positioning and international maritime communications satellites, reflected off the

ocean to detect wave weights and currents. The tests were successful and some of those engineers believe those same transmissions could be used to detect ships, if a large enough antenna could be lofted.

U.S. DOD's Defense Advanced Research Project Agency is looking at developing just such an antenna to be placed on/in the skin of the high altitude airship and similar craft. One of the limiting factors of using such craft for maritime surveillance is the large size, weight, and power requirements to place an air and/or maritime surveillance radar on board that would be capable of capitalizing on the high altitude, and its commensurate long line of sight.

Using satellite transmission-based PCL techniques as just described would mean there would be no need to carry a large radar. This concept is being discussed, but no additional tests have yet been run. Hopefully, this concept will be investigated further.

Other technologies being considered for the approaches zone (that area extending from beyond line of sight to approximately 100 miles offshore) include high-altitude, long-endurance unmanned air vehicles, such as a marinized Global Hawk; medium-altitude, long-endurance unmanned air vehicles, such as the Predator-B/Mariner; and airships in a variety of configurations, including hybrids and unmanned versions. Also under consideration: aerostats capable of being launched from vessels underway and capable of remaining on station during all weather except hurricanes; buoys equipped with a host of sensors, including AIS, surface wave radars, signals intelligence systems, and remote-control cameras; and remotely piloted/unmanned surface and subsurface vessels.

No one system is seen as being able to do it all, but a judicious mix of the above systems should allow the United States to detect, identify, track, and interdict nearly all vessels that approach its coasts. Indeed, there is no silver bullet, but there are some pretty effective copper and silicon ones!

About the author: Mr. George Guy Thomas is science & technology advisor, Maritime Domain Awareness Directorate, U.S. Coast Guard. A retired Navy commander, he has published several articles on technical intelligence, reconnaissance and surveillance systems, and electronic warfare. Mr. Thomas is a distinguished graduate of the Naval War College, he holds a Master's degree (High Honors) in Computer Information Systems from Bryant College. He is a member of Delta Mu Delta national graduate school honor society.